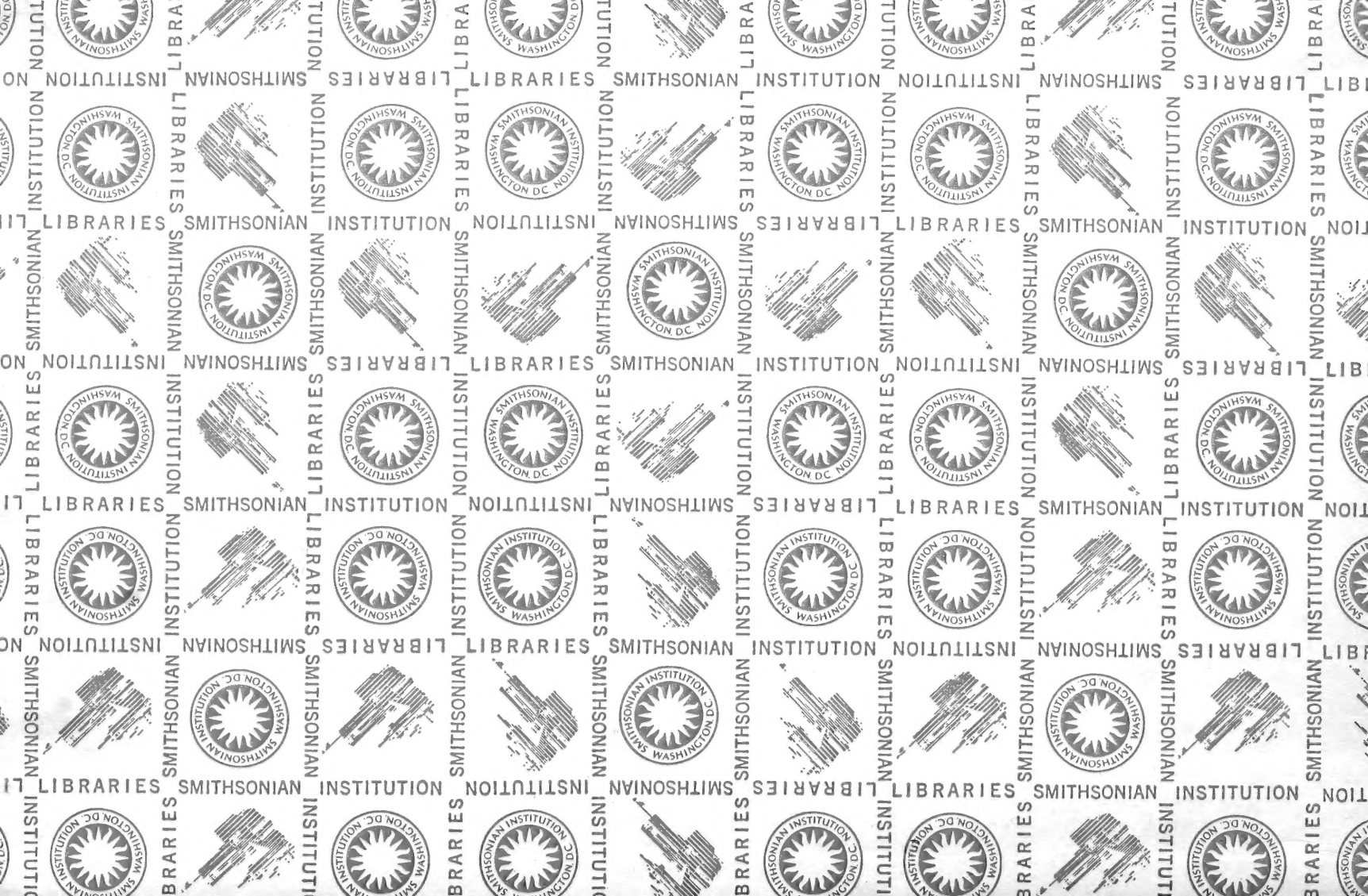
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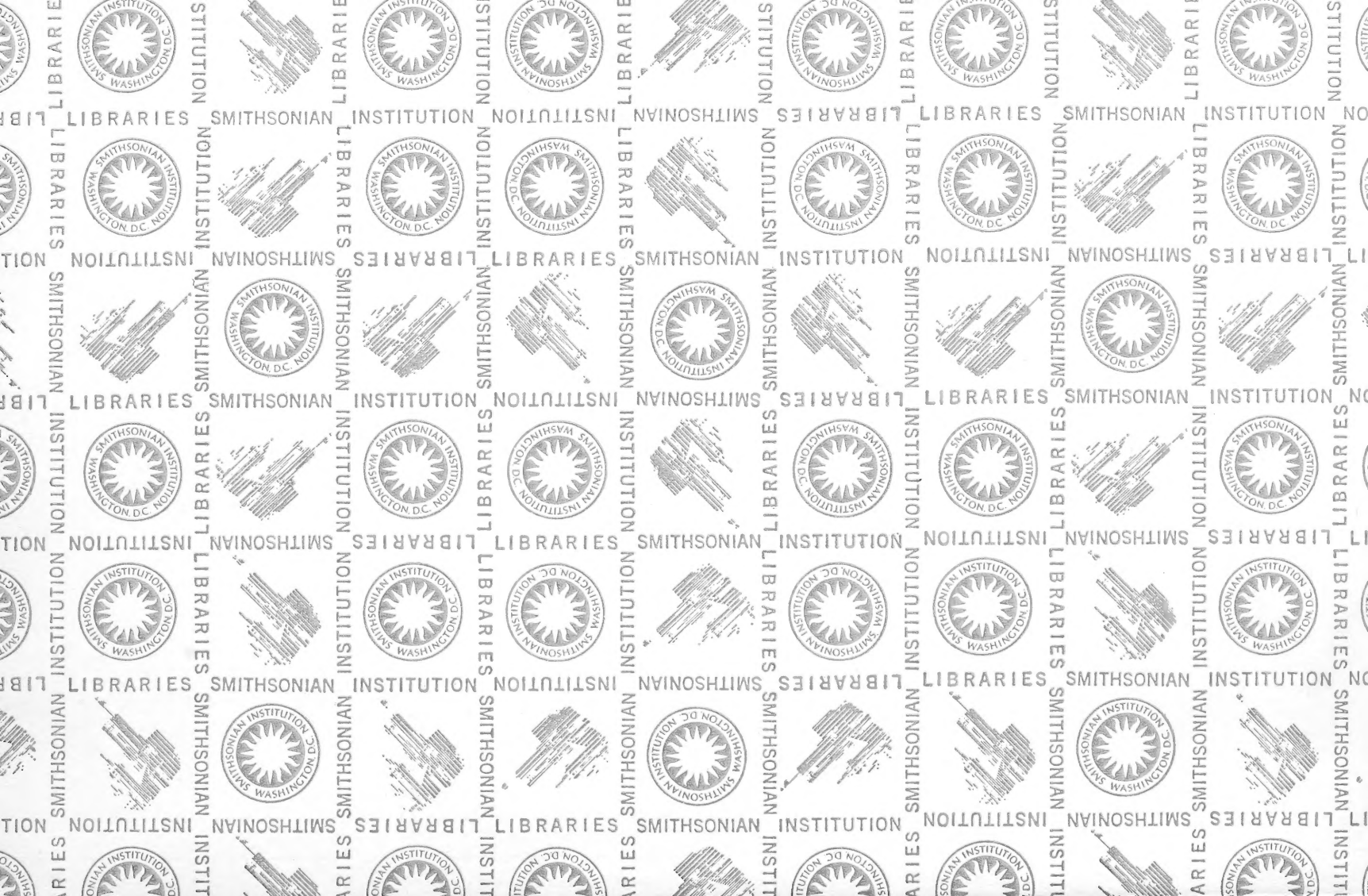
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BULLETIN

OF THE

New York State Museum

FREDERICK J. H. MERRILL, *Director*

VOL. 6. No. 27.

May 1899

SHADE TREE PESTS

IN

NEW YORK STATE

BY

EPHRAIM PORTER FELT, D. Sc.

State Entomologist

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

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CONTENTS

SHADE TREE PESTS IN NEW YORK STATE

The annual depredations of the white marked tussock moth, the severe injuries inflicted by the forest tent caterpillar not only on forest trees and sugar orchards but also on shade trees, the insidious work of wood and bark borers and the extreme destructiveness of the elm leaf beetle, have all combined to emphasize the vital importance of protecting shade trees in the cities and villages of this state.

Injuries to trees. Some idea of the destructive powers of shade tree pests may be gained by examining their past history. Albany and Troy have each lost over a thousand magnificent trees in the last five years through the work of the elm leaf beetle and its associates. The elms were not only defoliated once, but a second crop of leaves was frequently stripped from the trees, thus causing speedy death. About nine years ago thousands of trees were killed in Brooklyn, N. Y., by the maple tree scale insect, and last year it was so abundant as to inflict much damage in many localities. The white marked tussock moth yearly defoliates many valuable trees, in spite of the fact that a few well directed efforts would keep it in check. In most cases no effort is made to control the outbreak of an insect till it has about passed the remedial stage. That is, the insect has nearly completed its growth and therefore can not be poisoned through its food, or else the foliage is so completely devoured that there is very little to poison. Those interested in the welfare of trees, should be posted in regard to their principal insect enemies and be prepared to give their trees adequate protection.

Object of bulletin. The aim of this bulletin is to present in concise form the characteristics of the more destructive species attacking our principal shade trees, both through descriptions and figures, and to indicate methods of controlling them. If the insect does not agree with any of those described in the following pages, examples should be submitted to the state entomologist and the proper method of controlling it learned. In case of a very severe attack, it would probably be wiser to fight on general principles and ascertain more in regard to it later, for a host of caterpillars can cause irreparable damage in a few days if left alone. It is much easier to control insects than to subdue them after they have obtained a good start.

WHITE MARKED TUSSOCK MOTH

Notolophus leucostigma Sm. and Abb.

This species feeds readily on elm and maple leaves, displaying a special preference for those of horse chestnut and linden, and frequently does considerable damage. Last year it was a scourge in some cities of this state.

Characteristics. The caterpillar has a coral red head, a pair of long black plumes just over it, a single one at the opposite extremity of the body, four delicate yellowish or white brush-like tufts on the back, and just behind them, separated only by a segment, two small, retractile, red elevations. Along the back, except for the tubercles and tufts, there is a broad black band bordered by yellowish tubercles. A black line indicates the position of the spiracles or breathing pores, and below this latter line it is yellow, the legs being paler (fig. 1, *a*). This gives the

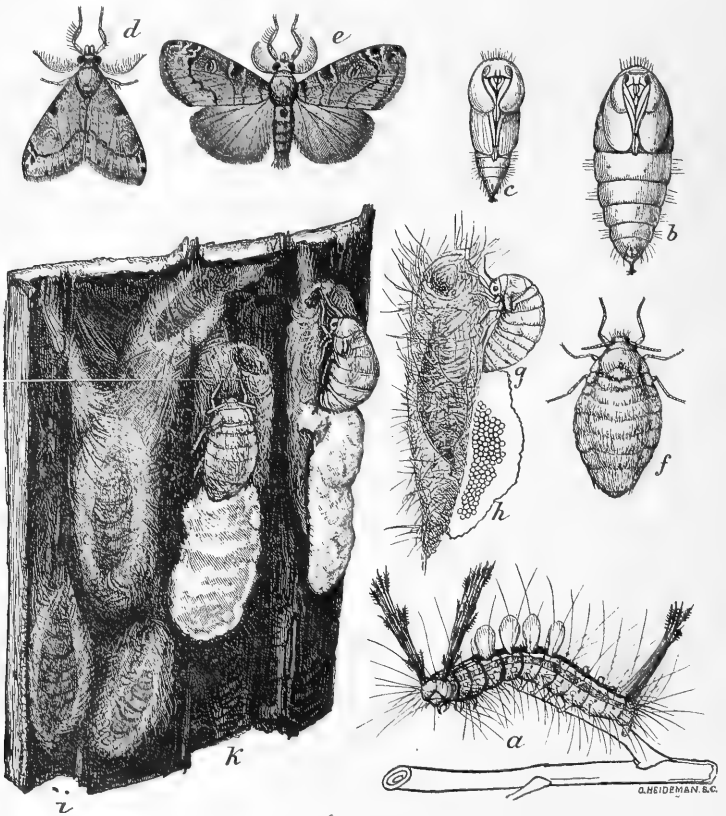


Fig. 1 White marked tussock moth. *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths laying eggs—all slightly enlarged (after Howard [Division entomology], U. S. Dep't agriculture, year book, 1895).

general appearance of the caterpillar when it is half or two thirds grown, and at a time when its depredations begin to be apparent. The recently hatched larva is a pale yellowish or whitish creature with long, irregular hairs. As it feeds, increases in size and casts its skin from time to time, one after another of the characteristics of the full grown larva are assumed.

When maturity is reached, the larvae spin their thin cocoons in the crevices of the bark (fig. 1, *i*), interweaving their long hairs, and within this shelter transform to yellowish white pupae more or less shaded with dark brown or black (fig. 1, *b*, *c*).

The difference between the sexes is strikingly shown by comparing in figure 1, *d* and *e*, illustrations of the male, with *f*, that of the female. The former is a beautiful moth with large feathery antennae, the legs tufted, and the wings and body delicately marked with several shades of gray and grayish white. On the other hand the female is a nearly uniform gray, with simple antennae and but rudimentary wings.

After remaining from 10 to 15 days in the pupa state, the wingless female emerges and deposits her eggs on the empty cocoon under a conspicuous white mass of frothy matter (fig. 1, *h*, *k*), which soon hardens and forms a very effective protection. The individual egg is nearly spheric, about $\frac{1}{25}$ in. in diameter, white or yellowish white, and with a light brown spot surrounded by a ring of the same color.

Life history. The winter is passed in the egg state, the young, emerging about the latter part of May in this latitude, feed on the under side of the leaves at first and complete their growth in about a month, the transformation to the pupa state occurring the latter part of June and early in July. In Albany there is normally but one annual generation, but in New York city and vicinity there are two broods each season.

Remedies. The simplest and most satisfactory remedy is found in gathering and destroying the egg masses. As the eggs are in a compact mass, which is conspicuous and readily torn from the supporting cocoon, either by hand or by some form of a scraper, the task is quickly and easily performed. On account of the females being wingless, a tree once thoroughly cleaned will not become reinfested very soon if larvae are not abundant near by, and even then a band of loose cotton bound tightly around the trunk will prevent their ascending and a consequent reinfestation. This band is of value only when the tree is clean, and has not the slightest effect on caterpillars already in the trees unless they are shaken down. Only the eggs should be collected and destroyed, otherwise many beneficial parasites would be killed in cocoons not bearing egg masses. The egg masses may be collected any time after their deposition in the summer and prior to their hatching in the spring. The best time is in early spring just before the leaves appear, as this gives an opportunity for parasites to escape before the cocoons are touched and the absence of leaves facilitates the detection of the egg masses. In Rochester, N. Y., prizes were offered in 1894 to the school children gathering the largest number of egg masses with

most excellent results. In cities and villages where this insect is the only important enemy of shade trees, this system or the payment of a bounty on eggs collected would undoubtedly result in the pest being kept in subjection at a comparatively small outlay. It may also be controlled by spraying, which will be discussed under a separate heading.

ELM LEAF BEETLE

Galerucella luteola Müll.

Along the Hudson river valley as far north as Troy, this insect is the worst enemy of the elms, specially the European forms, though under certain conditions it may inflict much injury on the American elms. So far as known, this pest has not made its way to any great distance from the Hudson river in this state, excepting on Long Island.

Characteristics. The elm leaf beetle is about $\frac{1}{4}$ inch long with the head, thorax and margins of the wing covers a reddish yellow. The coal black eyes and median spot of the same color on the head are prominent. Its other black and yellowish or yellowish green markings may be made out by aid of figure 2, plate 1. They are usually constant in the adult, but the colors are quite variable during life and change more or less after death. In some beetles emerging from winter quarters, the conspicuous greenish yellow stripes of the wing covers are nearly black. In the early spring the beetles are found in houses, sheds and other shelters where they pass the winter. On the appearance of the foliage, from about the first to the middle of May, the beetles fly to the trees and, after eating roundish holes (pl. 2, fig. 1) for some time, deposit their yellowish eggs in irregular rows side by side, forming clusters of from 5 to 26 or more (pl. 1, fig. 3), over half the total number of eggs laid being deposited between about the 10th and 20th day after oviposition begins, comparatively few being laid from the 20th to the 30th days.

The young grubs (pl. 1, fig. 4), about $\frac{1}{20}$ inch long and well provided with black tubercles and rather long hairs of the same color, appear early in June and feed only on the under surface of the leaves (pl. 2, fig. 2). They complete their growth in from 15 to 20 days and the mature ones (pl. 1, fig. 5) may be recognized by the broad yellow stripe dorsally and a narrower stripe of the same color on each side, the yellow stripes being separated by broad dark bands thickly set with tubercles bearing short, dark colored hairs. The full grown larvae or grubs descend the trees and transform to orange yellow pupae (pl. 1, fig. 7) in the crevices of the larger limbs and trunks, and on the ground around the base of the trees, where they sometimes

form layers nearly half an inch deep. In such places they change to beetles in five or more days. Up to 1894 this was supposed to complete the life history of the insect in this latitude, but that year the late Dr Lintner discovered the presence of a second brood and subsequent observations have not only demonstrated this to be the rule but that under exceptional circumstances there may even be a partial third generation. The grubs of the second generation are destructive in August. The development of the first brood is governed to some extent by local conditions, and later in the summer there is considerable diversity even on trees of the same street. The bulk of the larvae may be pupating under some elms, while on others numerous eggs and young may be found. The various stages of this insect are passed so rapidly that close observation and a ready adaptation to conditions are necessary in attempting to control it.

Remedies. Since the beetles fly into the trees each spring, the application of bands of any substance around the trunk will not have the slightest effect in preventing attack. A band is of value only when it keeps an insect not already in the tree from ascending the trunk. Sticky fly paper has been placed around trees attacked by elm leaf beetles and many of the descending grubs were captured, but the number killed is but a drop in the bucket compared with the host that transform in safety above. The grubs may also be killed in large numbers as they lie in masses around the trunk. But even this can be considered as but a palliative measure, for a considerable proportion must escape, and as the beetles are so prolific (one may deposit over 600 eggs), it requires comparatively few to cause serious injury. Another so called remedy is plugging the afflicted trees with sulfur or other compound. The idea being to introduce into the trunk, where it will be taken up by the sap, some substance which will not injure the tree and yet kill the insects, or at least render the foliage distasteful to them. It is a plausible theory but has no foundation in fact. The only thoroughly satisfactory treatment for this insect is found in spraying the foliage with some arsenical compound. The method of doing this will be treated of more fully on following pages.

ELM BARK LOUSE

Gossyparia ulmi Geof.

Elms along the Hudson river are unfortunate in suffering from a bark louse, which, like the elm leaf beetle, is an imported insect and prefers European elms.

Characteristics. The affected trees are easily recognized in midsummer by their blackened appearance, which is caused by the growth of a fungus in the honey dew excreted by the bark louse and covering the foliage, limbs and ground beneath. In sunlight, minute drops of the secretion may be seen falling in showers from the clusters of insects, giving an idea of the drain this species must be upon the vitality of an elm. The limbs which have harbored this bark louse for a few years begin to die, the tree itself shows signs of weakness, and when it is attacked by both the elm leaf beetle and this bark louse, succumbs shortly.

The adult females are rather conspicuous and may be found on the under side of the smaller branches, frequently clustered in masses and appearing not unlike certain lichens (pl. 2, fig. 3). In June each is about $\frac{1}{10}$ inch long, oval in outline, with the extremities slightly pointed, and if crushed causes a reddish stain from the contained ova. The body is surrounded by a mass of white, woolly secretion and the segmentation is also indicated by the same substance. The minute yellow young make their appearance early in July and soon settle for a time on the greener twigs and along the principal veins of the leaves. In the autumn the back of the partly grown bark louse is covered with spiny processes secreting a white waxy matter. At this time most of the insects forsake the leaves and settle for the winter in crevices of the bark. In the early spring activity is resumed and the round of life completed.

Remedies. As this insect is one of the sucking forms, securing its nourishment through slender hair like mouth parts from the under-lying tissues of the bark, its food can not be poisoned and recourse must be had to contact insecticides, as will be explained later.

TENT CATERPILLARS

Clisiocampa disstria Hübn.: *Clisiocampa americana* Fabr.

Complaints are received each spring of injuries to maples and other shade trees by caterpillars. Examples submitted show that the offender is more frequently the forest tent caterpillar, though occasionally its near relative, the apple tree tent caterpillar, may be a partner in the mischief.

Characteristics. The caterpillars of the two species may be readily distinguished. The forest tent caterpillar has a blue head and a row of 10 silvery white spots down the back, as represented in figure 2. The apple tree tent caterpillar has a black head with a bluish white stripe along the back. The former spins its web against the bark of a tree

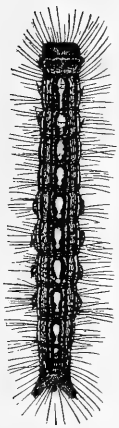


Fig. 2 Forest tent caterpillar (after Riley).

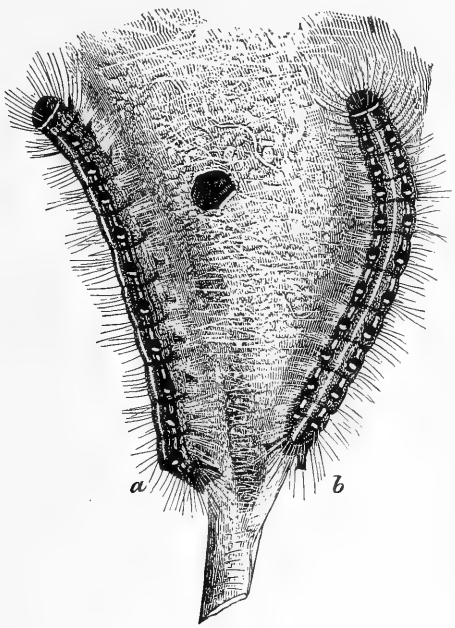


Fig. 3 Apple tree tent caterpillars and nest (after Riley).

and on this account its threads are frequently overlooked, while the conspicuous tents (fig. 3) of the latter are familiar objects in many orchards and in wild cherry trees along the roadside.

Life history. The life histories of these two species are quite similar. The eggs which are deposited in broad belts in June or July around the smaller twigs, those of each species being easily distinguished from the other (see fig 4, 5), do not usually hatch till spring. The caterpillars appear early and feed most voraciously, the forest tent caterpillar completing its growth in June or the first of July, while the other matures a little earlier. The moths emerge the latter half of June or the first half of July and deposit their eggs from which caterpillars come another spring.

Remedies. The caterpillars of both of these species are very susceptible to arsenical poisons and can be readily controlled by spraying, as will be described later. In case the expense attendant upon this

operation is too great, something may be done by jarring the caterpillars from the trees, first applying a broad sticky band, e. g., tar on thick building paper, tangle foot fly paper, etc., or a band of loose cotton around the trunk so as to prevent the dislodged enemy from ascending. The jarring can be performed best on a bright day when the caterpillars are feeding on the leaves, as they are then much more easily disturbed. Send a boy into the tree with a padded mallet with instructions to begin near the top and jar the depredators from the limbs. Those hanging persistently by long threads may be swept down with a pole. Kill the caterpillars as they assemble below the sticky band in order to guard against their bridging it when present in numbers, and repeat the jarring at intervals of a day or two till the trees are comparatively free from the pests. The caterpillars of the white marked tussock moth can also be treated in this manner. Many forest tent caterpillars can be killed by spraying with kerosene emulsion when they assemble in large masses on the lower limbs and trunks for the purpose of molting. At this time, they may also be brushed down or forced to drop by the judicious use of a torch. Apple tree tent caterpillars, on account of their remaining during damp or cold weather in their webs, can easily be removed and destroyed at these times.

Fig. 4 Egg belt of forest tent caterpillar, showing a few exposed eggs, enlarged.

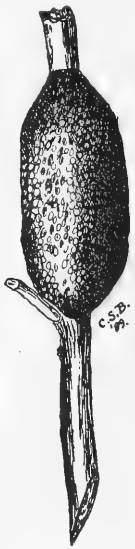


Fig. 5 Egg belt of apple tent caterpillar, enlarged.

FALL WEB WORM

Hyphantria cunea Drury

During the latter part of August in this latitude, conspicuous webs are frequently seen inclosing the tips of branches of many trees, each web containing brown skeletonized leaves. This is the work of the fall web worm and may be easily distinguished from that of the apple tree tent caterpillar not only because they occur later in the season but the tips of the branches are inclosed and the caterpillars feed within the webs, while those of the common apple tree species use the web only as a retreat when not feeding.

Remedies. These gregarious caterpillars are easily destroyed within the web by removing and burning the infested portion of the limb. They can also be controlled by the use of poisons.

BORERS IN TRUNK AND LIMBS

There are several very injurious borers infesting the trunks and branches of elm and maple trees, and since they work under the bark or within the wood, it is extremely difficult to control them.

Indications of attack. The presence of these insidious enemies is usually indicated by one or more dead branches and a more or less sickly appearance of the tree. Borings or "saw dust" may be found around the base of the tree in some instances, and in bad attacks large patches of loose bark may be found. On removing or cutting into the bark, the familiar work of borers is exposed (pl. 3, fig. 3), and the white, usually legless, somewhat flattened grubs may be seen lying in their burrows.

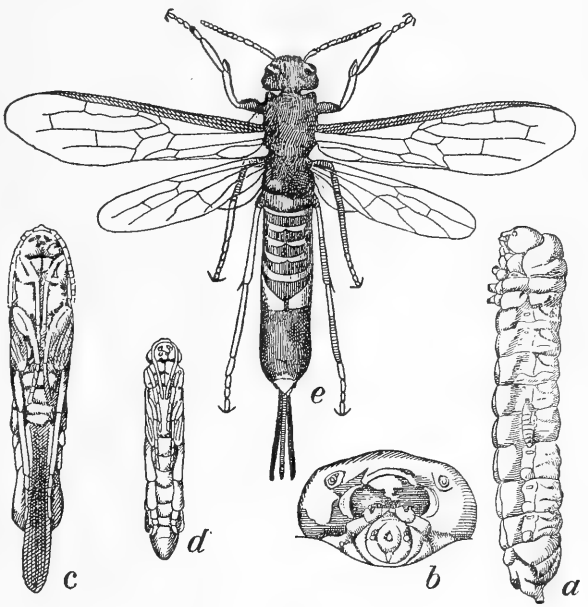


Fig. 6. Pigeon Tremex; *a*, larva showing the Thalessa larva fastened to its side; *b*, head of larva; *c*, pupa of female; *d*, male pupa; *e*, adult female—all slightly enlarged.

Elm and maple borers. The parent of the maple tree borer, *Plagionotus speciosus* Say, is a handsome black beetle with yellow markings and is represented on plate 3, figure 1. The adult of the more common of the elm tree borers, *Saperda tridentata* Oliv., is a slaty colored beetle with dull reddish markings and is represented on plate 3, figure 2. The thick fleshy grubs of several curculios or weevils are sometimes found in numbers just beneath the bark of elms and occasionally cause considerable injury.

Pigeon Tremex. The larva of another insect known as the pigeon Tremex, *Tremex columba* Linn., or horn tail, runs large burrows through the wood of elms and other trees, specially those which have been weakened by the attack of some other insect. Its various stages are repre-

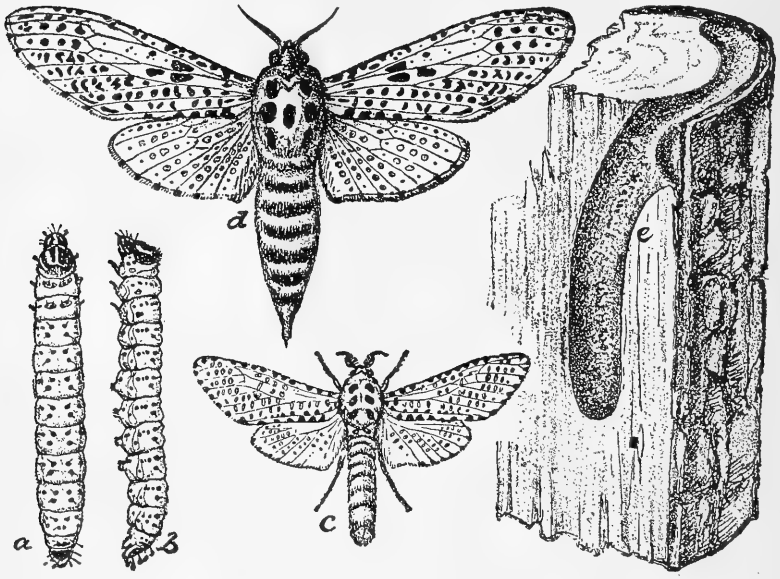


Fig. 7 Leopard moth: *a*, *b*, dorsal and lateral aspects of caterpillar; *c*, *d*, male and female moths; *e*, burrow of caterpillar (after Pike).

sented in figure 6. The female is a magnificent brown insect with yellowish markings and is occasionally found attached to a tree by its inserted ovipositor.

Leopard moth. In the vicinity of New York city there is another borer very injurious to elms and maples. It is the caterpillar of the leopard moth, *Zeuzera pyrina* Fabr., a species which has recently made its way to our shores and is proving a serious pest. This insect and its work may be recognized by the accompanying illustration, the moth being white marked with black.

Remedies. One of the best preventives of borers is to maintain the trees in a flourishing condition. The prompt removal and destruction, in order that no insects may escape to propagate their kind, of infested trees or limbs will do much to keep these pests under control, and in the case of those suffering from a severe attack, is almost the only remedy. The handsome beetles of the maple tree borer are abroad during June, July and August, their eggs being deposited the latter two months. The adults of the elm borer may be found during May and June, the eggs being laid the latter month. If the attack has not proceeded too far and the trees are of sufficient value, a considerable degree of protection will probably be obtained by coating the trunk of the maple and the trunk and larger limbs of the elm with a solution of soft soap and carbolic acid during the period these beetles deposit eggs, thus preventing further infestation. This solution may be applied either as a spray or with brushes and should be renewed as often as washed off by rains during the period of oviposition. In the case of more valuable trees, specially those infested with the fleshy grubs of curculios or weevils, it may pay in some instances to shave away the bark over the infested portions, till living tissues are reached, and kill the borers by the application of kerosene emulsion, and then protect the treated areas from drying by applying a coating of some thick, adhesive substance, e. g. a mixture of cow dung and lime, grafting wax or other substance. Experiments conducted in France have shown that much more of the bark may be removed, even strips two inches wide, and the trees not only recovered but the borers were killed by the vigorous growth made in the effort to heal the wounds. In case of very severe attacks, this would certainly be worth trying. The best results would probably be obtained if the operation was performed in the spring. The pigeon Tremex works so deeply in the wood, that little can be done to arrest its attack, but fortunately it infests only sickly trees, as a rule, and therefore simply aids in the final destruction of a tree.

Serious injury by the leopard moth can only be prevented, in regions where it occurs, by constant watchfulness. Indications of its presence should lead to immediate examination and the digging out of the borer or the destruction of the infested limb. Some of the more valuable trees in the parks of New York city are protected from this pest by killing the caterpillars in their burrows with a wire and when this is not possible, resort is had to carbon bisulfid, which is injected into the burrow by the aid of a long nosed oil can and the opening is then closed with putty.

COTTONY MAPLE TREE SCALE INSECT

Pulvinaria innumerabilis Rathv.

Maples and occasionally elms suffer severely at times from the attacks of this scale insect. A few full grown individuals are represented in the accompanying figure. The insect may be recognized by its brownish scale at one end of a large white cottony mass. In bad attacks, the insects may form festoons along the under side of the smaller limbs.

Fig. 8 Cottony maple tree scale insect.

Remedies. Like the elm bark louse this species obtains its food by suction from the underlying tissues and therefore can not be poisoned. The cottony mass covering the body of the female protects her from contact insecticides, consequently little can be done till the unprotected young appear in July, when spraying with kerosene emulsion or whale oil soap solution will be found most effective.

VALUE OF OUR NATIVE BIRDS

The valuable services rendered by our native birds should be more generally recognized. It is a matter of record that after the introduction of the English sparrow, most of our native birds were driven from the cities and that the tussock moth caterpillars, previously hardly noticed as pests, became destructive. It is very true that prior to the introduction of the English sparrow, a measuring worm had been a pest in various cities, but this is an additional proof of the effect birds may have upon insect life. In the same way there are a number of birds known to prey on the tent caterpillars and were these friends of man accorded the protection and encouragement they deserve, instead of being hunted and driven away, it is very probable that the ravages of these pests would be much less severe than at present. Robins, orioles, chipping sparrows, cat birds, cuckoos, the red eyed, white eyed and warbling vireos, cedar birds and nuthatches have been observed feeding on forest tent caterpillars by Miss Soule. "The nuthatches would stand by a patch of larvae lying close together below a tar band on a tree and eat so voraciously and with such an entire abandonment of self-consciousness that I could go close and put my hand on them before they would fly. This experience was repeated several times."[a] The

[a] Weed, C. M. New Hampshire agricultural experiment station. Bulletin 64. April 1899 (cites and quotes Miss Soule)

value of birds in keeping other pests under control is also strikingly shown in the experiment conducted by Mr E. H. Forbush, ornithologist of the Massachusetts board of agriculture. In a typical orchard at Medford, Mass., a little trouble was taken to attract the native birds, the nests of the English or house sparrow being destroyed. The results were greatly in favor of protecting our indigenous forms. In the neighboring orchards it was evident that canker worms and tent caterpillars were very numerous, but in the orchard in question, the trees were seriously injured in only one or two instances, though no attempt was made to control the insects by spraying or other artificial means.

Our native birds are undoubtedly of great value and will richly repay any slight effort that may be made for the purpose of attracting them to a locality. Winter birds may be induced to remain in a neighborhood by hanging in the trees pieces of meat or partially picked bones, and will spend much time in searching out and devouring numerous insects and their eggs, relying on the meat only when conditions are unfavorable for obtaining insect foot. Migratory birds may be induced to remain in larger numbers in a locality by providing them with suitable nesting places and materials, and by protecting them from cats and cruel boys. Thickets in the vicinity will afford shelter for certain species and if a few mulberry trees are set out, their fruit will serve to protect cherries, as the birds are said to eat the mulberries by preference. Most of these suggestions are taken from a very practical paper by Mr Forbush.

SPRAYING TREES

Though it is rather costly to spray trees in a thorough manner, in the case of the elm leaf beetle at least, it is much more satisfactory than any other method of fighting the pest and possesses the additional advantage of also controlling other leaf feeding species.

Rules for spraying. Apply the poisonous mixture at the time the insects begin to feed and on the part of the tree eaten. To control the elm leaf beetle it is best to spray once after the leaves have partly unfolded in order to kill the beetles before they can deposit many eggs, and a second time early in June for the purpose of destroying the grubs hatching from eggs laid by stray beetles. The second spraying must be on the under surface of the leaves because the grubs eat only the more tender under portions. They grow so rapidly and their development is affected to so great an extent by local conditions that the proper time for treatment must be determined largely by observation. If the eggs of the white marked tussock moth have not been removed, as advised on a preceding page, the caterpillars can be destroyed by spraying the latter

part of May or early in June, and, as in the case of the elm leaf beetle, it is advisable to throw the poison on the under surface of the leaves, since the very young caterpillars rarely break the upper epidermis. The same treatment is also very effective in the case of tent caterpillars, and in each case will be found valuable in proportion to its thoroughness. The aim of the operator should be to cover every leaf evenly with a mist like coating of the poisonous mixture. Spray till the leaves begin to drip but no more.

Proper apparatus. In order to do this work successfully one must possess a force pump capable of throwing a stream some distance, a number of feet of hose and a nozzle which will discharge a rather fine spray. There must also be something to hold the poisonous mixture, while a ladder facilitates the work greatly.

One of the best arrangements for hand work is most probably found in the spraying outfit mounted on wheels, so that it can be readily moved from place to place (plate 4). In most cases this takes the form of a box or barrel to which a force pump is firmly attached, and either provided with wheels or else designed to be placed in a wagon. In spraying tall trees 25 to 50 or more feet of $\frac{1}{4}$ or $\frac{1}{2}$ inch hose should be provided, while the addition of a brass or iron and brass extension 10 to 25 feet long adds materially to the value of the apparatus. It is also necessary to have a good nozzle which will not clog, but will produce a fine spray and which can be quickly adjusted to throw a coarse spray some distance if necessary. Such an outfit is of great service to any individual having considerable spraying to be done and undoubtedly it could be used to advantage by those desiring to make a business of spraying in a small way, as for example the treating of trees here and there for those in cities desiring their trees sprayed and not willing to purchase the necessary apparatus.

In the extended work against this insect conducted by cities and villages, it is desirable to have apparatus that will admit of more rapid work. This has led to the refitting of retired fire engines and the designing of more or less cumbersome outfits for this purpose. In all cases these makeshifts have been successful, though they are not so satisfactory in operation as those specially fitted for the purpose. Probably the best apparatus yet designed for spraying trees is that constructed under the direction of Dr E. B. Southwick, entomologist of the department of public parks of the city of New York, which is the form used in Albany. The whole outfit is represented in plate 5. It consists of a "Daimler" gasoline motor operating a Gould force pump—the motor and pump weighing but 300 pounds can be placed in the

bottom of a spring wagon along with the 100-gallon tank containing the poisonous mixture. This motor has the advantage of being almost noiseless in operation and is scarcely noticed by passing horses. It is very inexpensive to operate, as a gallon of gasoline is sufficient for a day and it requires little attention. The smallest size Gould 3-piston pump is the one used with the motor, though Dr Southwick now recommends a larger one in order to utilize the power more fully. This apparatus, with the tank, 400 ft of $\frac{3}{8}$ in. rubber hose and other necessary fittings, can be bought for $475. Other engines and pumps could undoubtedly be used and would give good results. This power can easily supply four lines of hose, though in Albany not more than two can be used to advantage in most places.

Mr P. C. Lewis, of Catskill, N. Y., who was in charge of the spraying in Albany in 1898, had several interesting devices for saving time and increasing the efficiency of the work. He designed a modified stepladder, about 16 feet high with platforms for two men and on two of its legs there are small wheels which permit ready removal from place to place. It is so constructed that it can be folded up and drawn behind the wagon when some distance is to be traversed. He also had in constant use a metal extension 25 feet long. The lower portion is composed of larger tubing, thus making it stiffer and at the same time rendering it easier to handle because the greater part of the weight is near the operator. This extremely long extension is suspended by a rope from the top of the modified stepladder in such a manner that the man has only to guide the stream. This arrangement does away with all climbing, as it was found impracticable to attempt to reach the tops of the taller trees. In many instances the huge steps could be placed in the middle of the street and the trees on both sides sprayed either from the steps or from the ground.

Arsenical compounds. These are effective against insects which devour portions of a plant and of value only when placed where they will be eaten. The following formulae are recommended:

Paris green	1 pound
Quicklime	1 pound
Water	100–300 gallons
London purple	1 pound
Quicklime	2–3 pounds
Water	100–300 gallons

The more common proportion is at the rate of 1 pound of the poison to 150 gallons of water, and less should be used on the more tender foliage like that of the peach or there may be serious injury. For the

elm leaf beetle, use 1 pound of the poison to 100 gallons of water. The addition of lime is not necessary, specially with paris green, but is a wise precaution as it neutralizes any free arsenic acid and thus prevents burning of the foliage.

Another substance which has received high praise and may come into general use after its good qualities become better known, is the arsenate of lead. The value of this compound as an insecticide has been brought out by numerous experiments, made in the extensive work against the gypsy moth. One advantage is that it can be applied in very large quantities without injuring the foliage. When properly prepared, it remains for some time suspended in the water, imparting a milky color, and also adheres to the leaves much longer than either paris green or london purple, and it promises to be of special value against the elm leaf beetle on this account. Its whiteness is another advantage, because of which, it is readily detected upon green foliage.

In order to obtain the best results, the poison should be prepared just before using, by dissolving 11 ounces of acetate of lead (sugar of lead) in 4 quarts of water in a wooden pail, and 4 ounces of arsenate of soda (50%) in 2 quarts of water in another wooden pail. As the acetate or sugar of lead dissolves rather slowly in cold water, the process can be hastened by using warm water. The resulting solutions should then be poured into the spraying tank containing enough water to give the desired proportions. In most cases this will mean turning them into 100 or 150 gallons of water, or but 80 gallons of water when spraying for the elm leaf beetles, though some recommend a larger proportion of the poison, and the same amounts to 100 gallons will kill the grubs.

Contact insecticides. These are substances which kill insects by contact and affect only those individuals touched. They are used against the elm bark louse, the woolly scale of the maple and other sucking insects.

Kerosene emulsion is one of the principal contact insecticides and is prepared by dissolving $\frac{1}{2}$ pound of hard soap in 1 gallon of boiling water and while it is still hot add 2 gallons of kerosene and emulsify by passing it rapidly through a force pump and back into the vessel till it assumes a creamy consistency and oil does not rise to the surface. Dilute with 9 to 15 parts of water and spray the young lice as they appear in the summer. In limestone regions where hard water is the rule, better results will probably be obtained by using the sour milk emulsion, which is composed of 2 gallons of kerosene and 1 gallon of sour milk emulsified by churning or passing through a pump. A mechanical mixture of the two may be used, if desired, with machines

now on the market for that purpose. Or a solution of 1 pound of whale oil soap to 4 gallons of water will be found effective. In the use of any of these compounds, thoroughness is of first importance. They may be sprayed on the insects, applied with brushes or in any other way that is convenient, provided the tree is not subjected to such drenching that the insecticide used will collect around the trunk and cause serious injury.

EXPLANATION OF PLATES

Plate 1

Fig. 1 Elm leaves showing eggs and work of young larvae.
Fig. 2 Elm leaf beetle (x2).
Fig. 3 Vertical and lateral view of eggs, very much enlarged.
Fig. 4 Young larva, very much enlarged.
Fig. 5 Full grown larva (x5).

Plate 2

Fig. 1 Leaf showing holes eaten by elm leaf beetle.
Fig. 2 Leaf skeletonized by elm leaf beetle grubs.
Fig. 3 Females of elm bark louse, slightly enlarged.

Plate 3

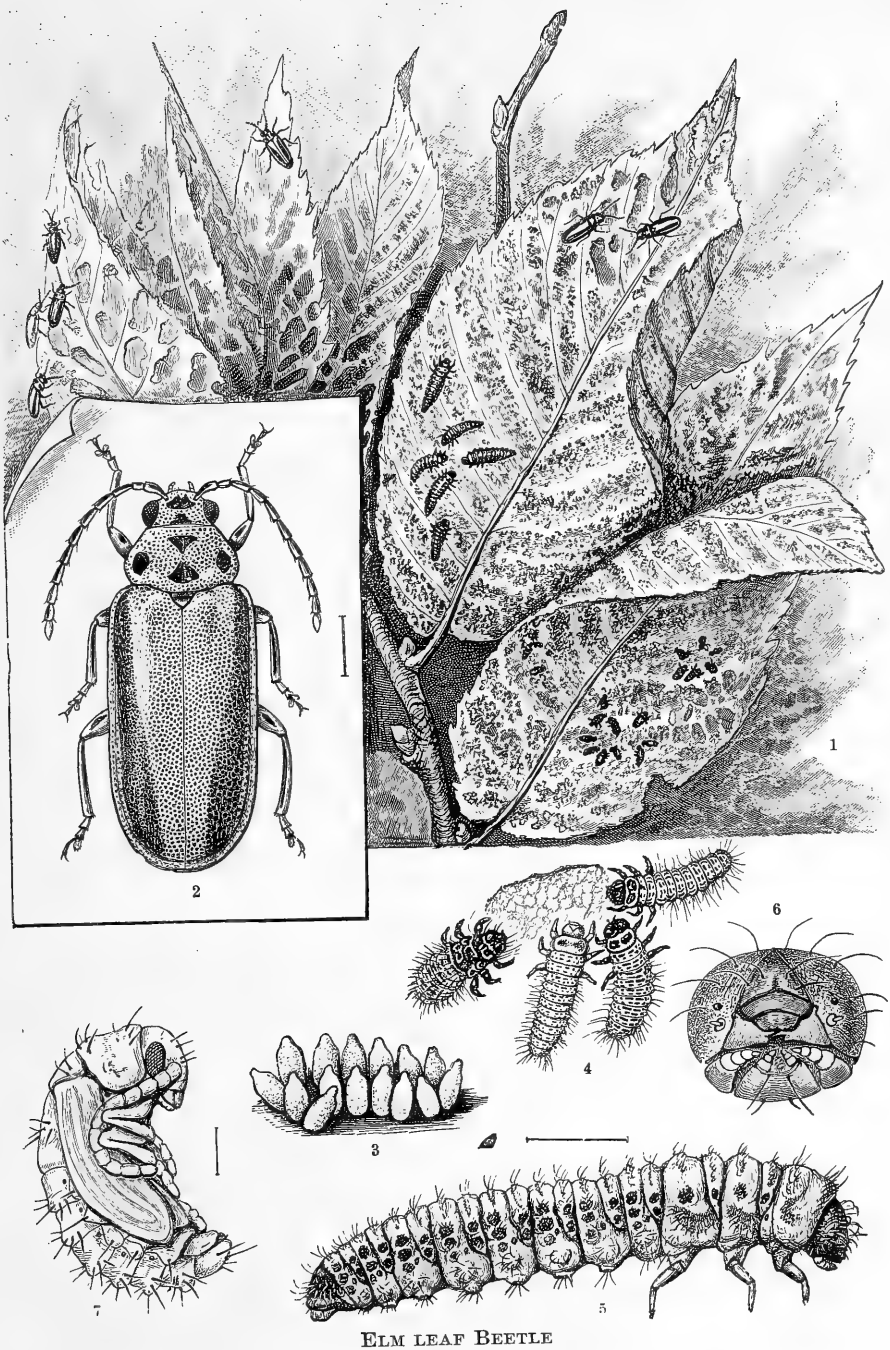
Fig. 1 Maple tree borer, *Plagionotus speciosus.*
Fig. 2 Elm borer, *Saperda tridentata.*
Fig. 3 Work of elm borers, *Saperda* and *Neoclytus.*

Plate 4

Hand spraying outfit in operation.

Plate 5

Power spraying outfit in operation.



ELM LEAF BEETLE

(After Howard [Division Entomology], U. S. Department agriculture, Year book, 1895)

Fig. 3 Females of elm bark louse (slightly enlarged)

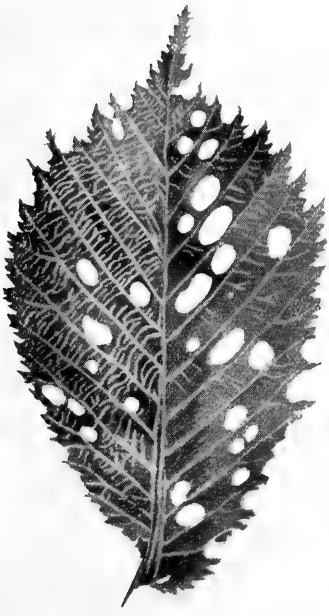


Fig. 1 Leaf showing holes eaten by elm leaf beetle

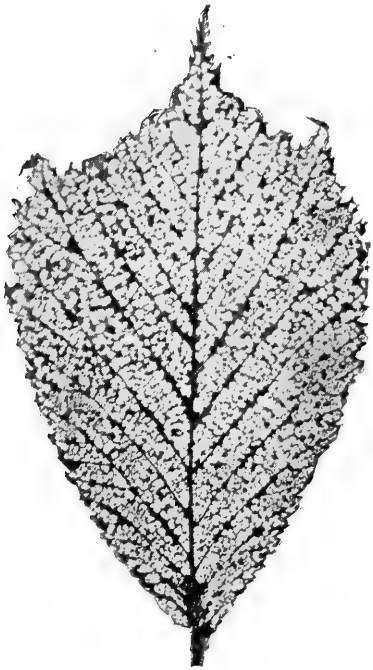


Fig. 2 Work of elm leaf beetle larvae

Fig. 1 Maple tree borer

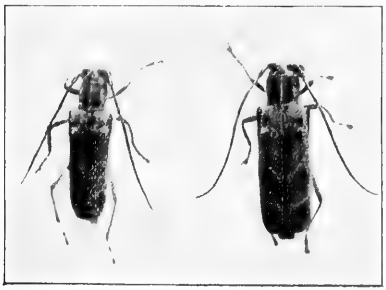
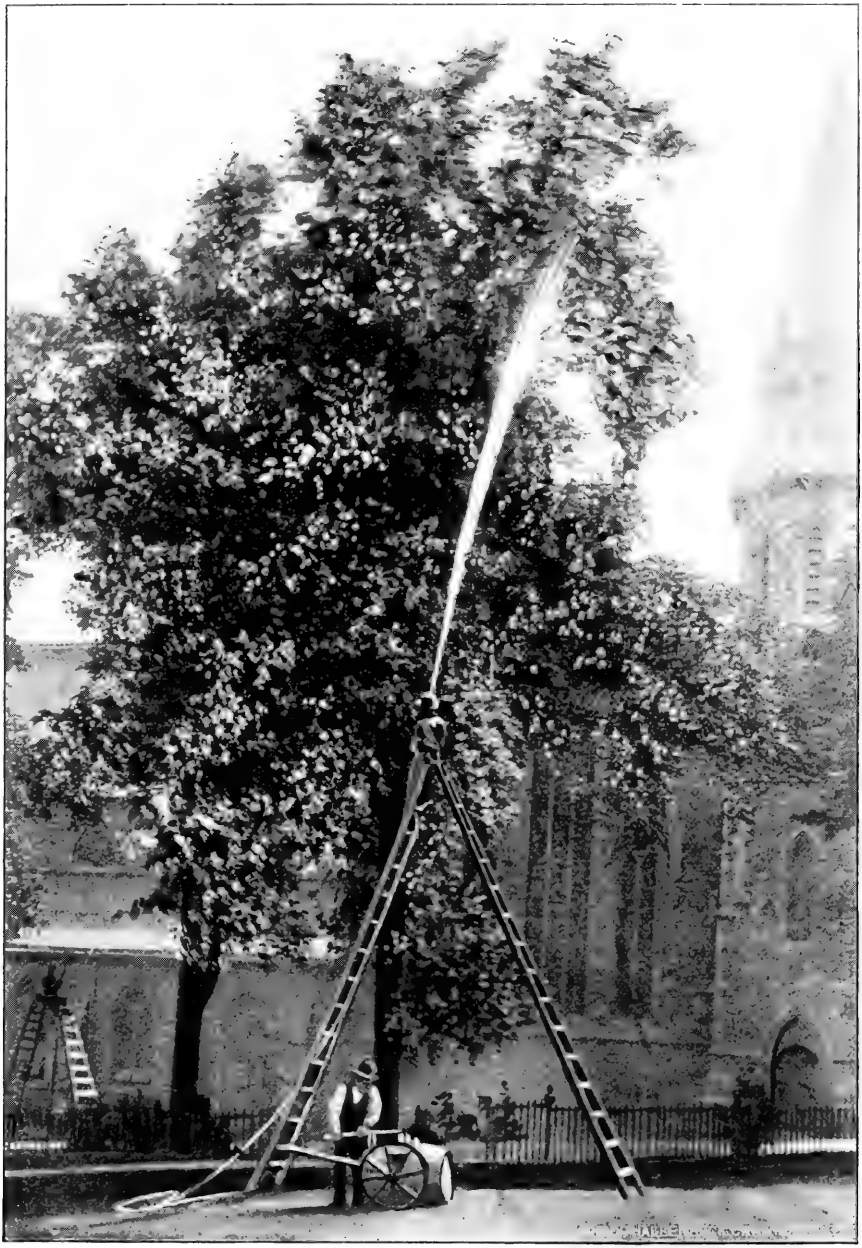


Fig. 2 Elm tree borer

Fig. 3 Work of borers



Hand spraying outfit in operation

Power spraying outfit in operation

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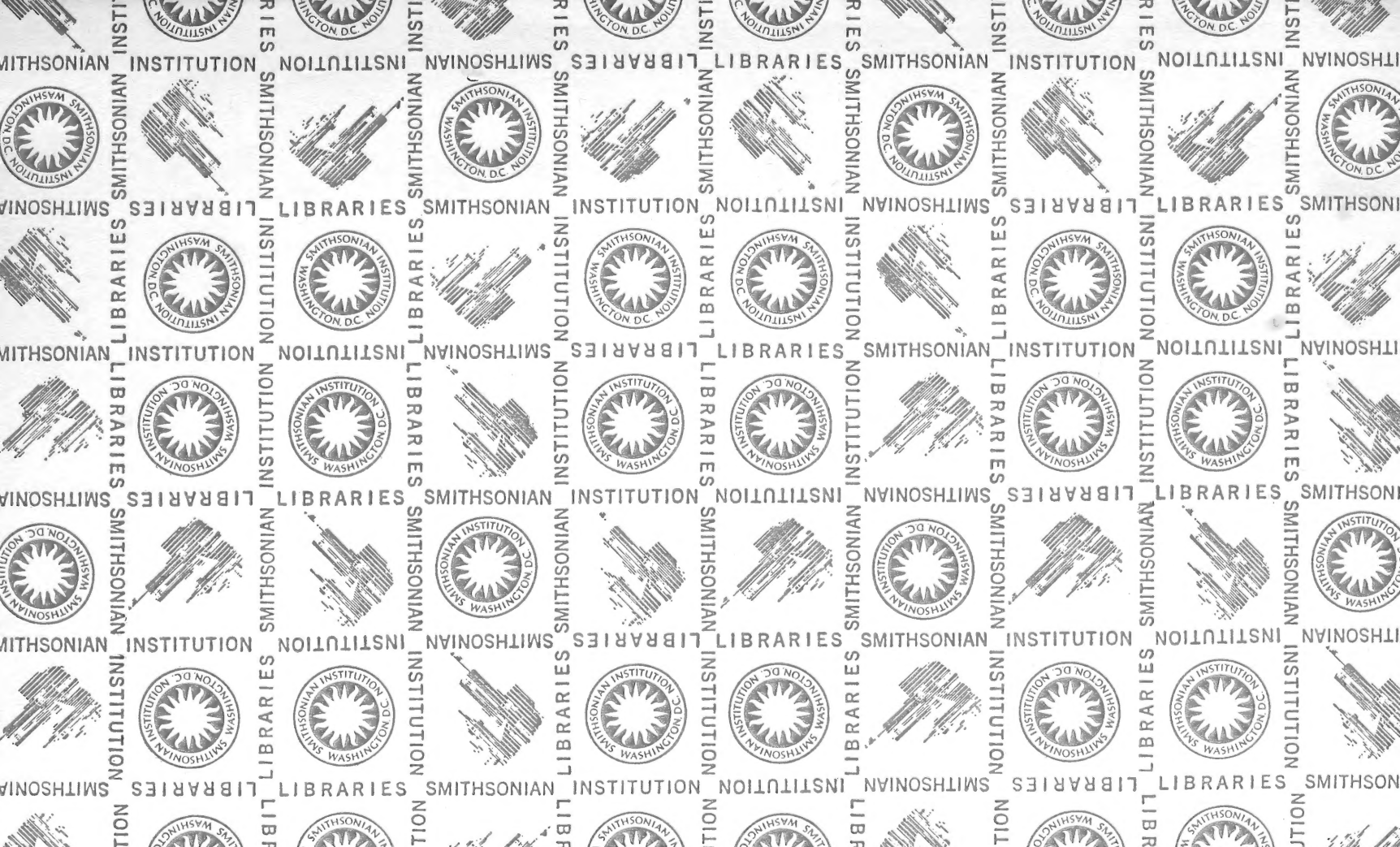
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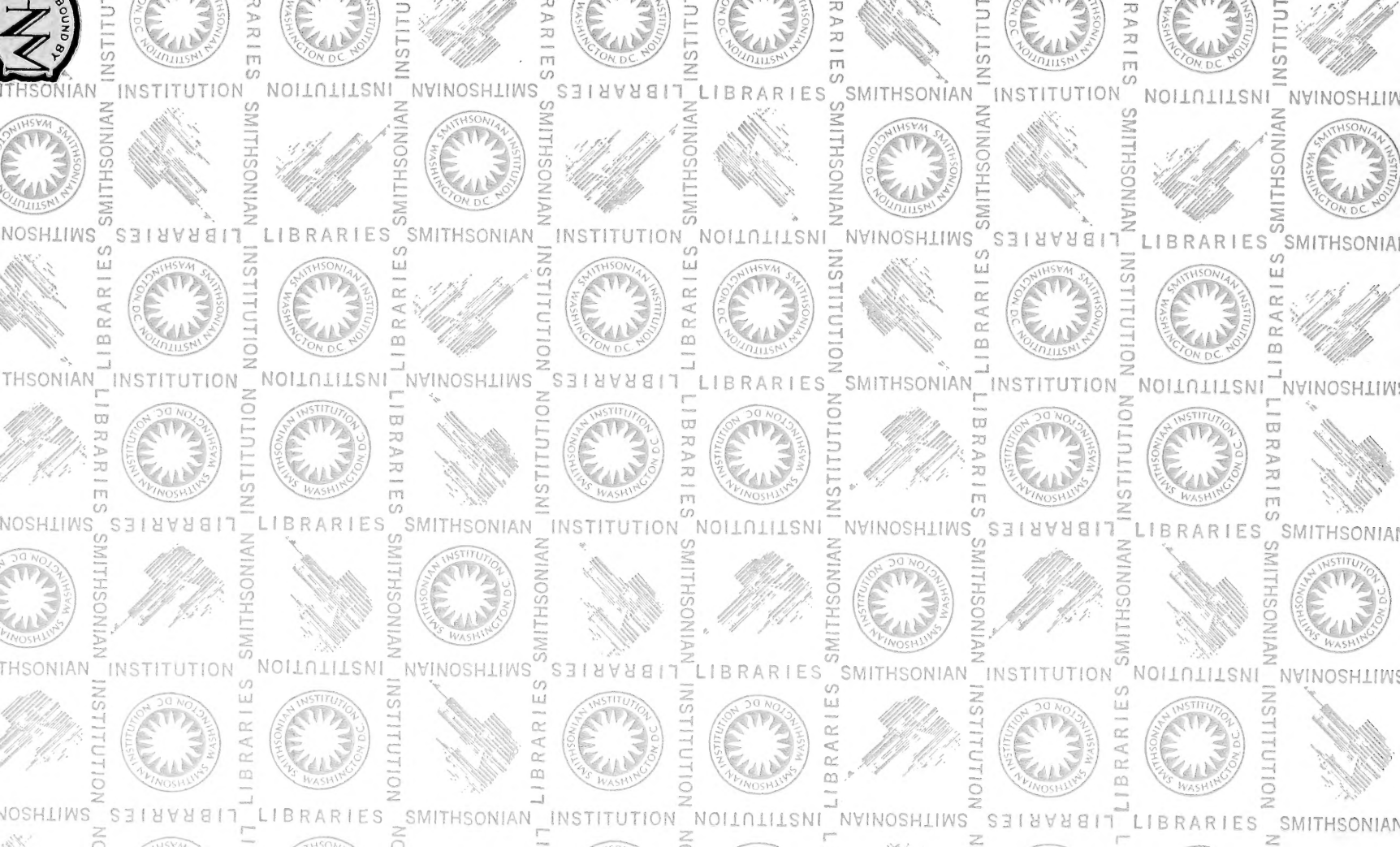
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